DISTRIBUTION, RELATIVE ABUNDANCE AND HABITAT UTILIZATION OF THE ARCTIC GRAYLING (*Thymallus arcticus*) IN THE UPPER BIG HOLE RIVER DRAINAGE, MONTANA

JUNE 21 TO AUGUST 28, 1989

Final Report - November 1990

by

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for the

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SUMMARY

This study focused on the distribution, relative abundance, and habitat utilization of native Arctic grayling (Thymallus arcticus) and possible dietary competition between grayling and introduced brook trout (Salvelinus fontinalis) in the Big Hole River and its tributaries along a 26 mile reach of the river near the town of Wisdom, Montana. The continuing decline of the Big Hole River Arctic grayling population, the last remaining population of fluvial grayling in the lower 48 United States, has led to increasing concern and has made studies such as this particularly important for the future management of this population.

Electrofishing was used to determine the distribution and relative abundance of young-of-the-year (YOY) Arctic grayling. Arctic grayling, brook trout, and mountain whitefish (Prosopium williamsoni) were measured and weighed and released in the area where they were captured. Stomach samples were collected from 47 grayling and brook trout with the gastric lavage technique. In areas where large concentrations of YOY grayling were captured macro- and microhabitat measurements were made to quantify the grayling's preferences with respect to habitat. Three different methods of electrofishing were used to determine preferred sites of grayling. The first two used a Coffelt BP-1C backpack electrofisher in upstream and downstream directions in 'intensive-use areas' that had been previously located. The third method utilized a series of stationary electrofishing grids. Microhabitat data derived through these three methods were compared to determine whether the method used affected capture site parameters.

Microhabitat sites were quantified with respect to depth,

velocity, substrate, cover, and proximity to riffles where grayling spawning may have occurred. Macrohabitat areas were measured to develop an index of availability for habitat parameters such as depth, velocity, substrate, and cover. These macrohabitat areas were located in areas that contained large concentrations of YOY grayling and may not represent the true habitat availability.

The east channel of the Big Hole River below the town of Wisdom had the highest concentrations of YOY grayling of the ten sections surveyed. The west channel of the river, also below Wisdom, and an irrigation ditch above Wisdom also supported relatively high densities of these YOY fish.

Young-of-the-year Arctic grayling increased in mean total length (TL±SD) from 2.52 (±.08) inches on July 6 to 4.08 (±.24) inches on August 28, 1989. This growth rate is quite similar to that presented by Skaar (1989) for this same area in 1988. Condition factors for age I and older grayling averaged 1.10 (±.20) which is higher than that reported for 1988 (Skaar 1989) and much higher than that reported for 1979 (Liknes 1981). This result indicates that the individual fish were in better condition in 1989 than they were in either 1979 or 1988.

Macrohabitat areas selected by YOY grayling were typically one riffle-pool-riffle complex and could be characterized as having sloughing banks, being in close proximity to relatively 'clean' substrate materials, having at least one pool in excess of 1.5 feet in depth, and having abundant cover (usually in the form of aquatic vegetation). Orange-colored 'spawning flags', marking the locations where Montana Department of Fish, Wildlife and Parks personnel captured spawning grayling in late April and early May of 1989, were often in close association with the macrohabitat areas where large concentrations of YOY grayling were captured.

Microhabitat areas selected by YOY grayling averaged slightly deeper and had higher velocities than the surrounding macrohabitat areas. Cover was typically within one foot of a

capture site and was most often (80%) aquatic vegetation. Aquatic vegetation and soil clumps were used in higher proportion than they occurred, while pools were used in lower proportion than they occurred. Substrate at microhabitat sites was 'cleaner' (less silt) and of larger particle size than was available in the larger (adjacent) macrohabitat units.

The three electrofishing methods produced differences in locations where YOY grayling were collected relative to upstream or downstream riffles within microhabitat areas. The fish collected while moving in an upstream direction with the backpack electrofishing unit were closer to the upstream riffle than fish collected with either of the other two methods. The same type of relationship was true for the fish collected while moving downstream, in that they were collected closer to the downstream riffle, while the fish collected in the grids were intermediate in distance between the two riffles. This suggests that the two methods requiring the samplers to enter and move about in the water may displace the fish from their selected habitats and that the fish collected with the grid method probably provide the most reliable data with respect to microhabitat utilization. This result also indicates the results presented by Skaar (1989) may be biased and need to be re-examined.

Age I and older grayling in the Big Hole River appear to select a higher proportion of surface food items than do brook trout in the same areas. Stomach content analyses showed very little dietary overlap between the two species which indicates there may be little competition for food between the two species during the summer months. There were no YOY grayling found in the stomach samples from brook trout, however, few stomach samples were obtained early in the study when grayling fry had recently emerged and would be most vulnerable.

Young-of-the-year Arctic grayling showed a high fidelity for specific riffle-pool-riffle complexes. The proximity of YOY grayling to known spawning areas, as well as the lack of movement for the majority of recaptured YOY grayling suggests that these

fish are fairly stationary through at least their first summer.

The Arctic grayling population of the Big Hole River is continuing a decline that threatens their continued viability. More work is needed to understand why this population has declined so drastically. Studies of the distribution, habitat use (throughout the year), interspecific competition, predation, thermal tolerances, and land and water uses in the Big Hole Valley that affect the grayling are examples of the work required to help managers understand and remedy the factors causing the demise of this unique and threatened fishery.

INTRODUCTION

The continued decline of the only known population of fluvial Arctic grayling (Thymallus arcticus) in the lower 48 states has caused increasing concern. Liknes (1981) cited dewatering, overharvest, and competition with brook trout (Salvelinus fontinalis) as the principle factors that may be contributing to the decline of the Arctic grayling in the Big Hole River. The severe drought conditions (low water and very high water temperatures) in the Wisdom, Montana section of the Big Hole River during the summers of 1987 and 1988 appear to have seriously impacted the grayling population there. From Fall 1986 to Fall 1989 the linear density of age I and older grayling in the Big Hole River declined from about 35 per mile to approximately 18 per mile (R. Oswald, pers. comm.).

The Montana Natural Heritage Program, the Montana Cooperative Fisheries Unit, the Montana Department of Fish, Wildlife and Parks (MDFWP), and the U.S. Forest Service, through a cooperative effort, provided funding, equipment, and logistical support for a study of the Big Hole River grayling. This study, which began in the Spring of 1988, emphasizes the early-life history requirements and habitat preferences of young-of-the-year (YOY) Arctic grayling in the upper Big Hole River and its tributaries near the town of Wisdom, Montana.

The first portion of this study was conducted through the summer of 1988 and provided information on the distribution and habitat utilization of YOY Arctic grayling (Skaar 1989). This report presents the results of the continuation of the 1988 study and focuses again on the distribution and habitat preferences of YOY grayling as well as the possibility of interspecific competition for food between Arctic grayling and the non-native brook trout.

STUDY AREA AND METHODS

Electrofishing with three types of systems was conducted on the Big Hole River and associated tributaries from June 21 to August 28, 1989 to collect information on the distribution and relative abundance of grayling and in an attempt to locate areas with high densities of YOY Arctic grayling for later habitat measurements. Ten sample sections (Fig. 1), ranging in length from 0.18 to about 5 miles, were electrofished from one to several times. Streamflow discharge ranged from about 2 cubic feet per second (CFS) in the smaller channels and tributaries in late July and August to about 70 CFS in the mainstem of the Big Hole River during high flows in late June (Table 1).

Two mobile electrode electrofishing systems and a series of stationary grid-type electrofishing units were used throughout the study. Three people operated the boat system, which consisted of a plastic flat-bottom boat (Coleman Crawdad model) equipped with a 120 volt gasoline-powered generator and a Harvey Leach rectifying unit with an attached negative electrode and mobile positive electrode. A Coffelt BP-1C backpack electrofishing system was used in areas where the boat system was not applicable (where the water was too shallow). Electrofishing grids were constructed to sample microhabitat utilization by YOY grayling in a manner similar to that described by Bain et al. (1985). All electrofishing systems were operated with direct (DC), non-pulsed current ranging from 75 to 500 watts. The boat system was used early in the season when higher discharges were present and for the majority of the sampling on Swamp Creek (sections A and B) and the Big Hole River proper (sections C,D, and E) where flows were seldom below 10 CFS. Electrofishing always proceeded downstream with the boat system, as the primary purpose in using the boat system was to quantify distribution and relative abundance of fishes and habitat measurements were not made in areas that were sampled with only the boat system.

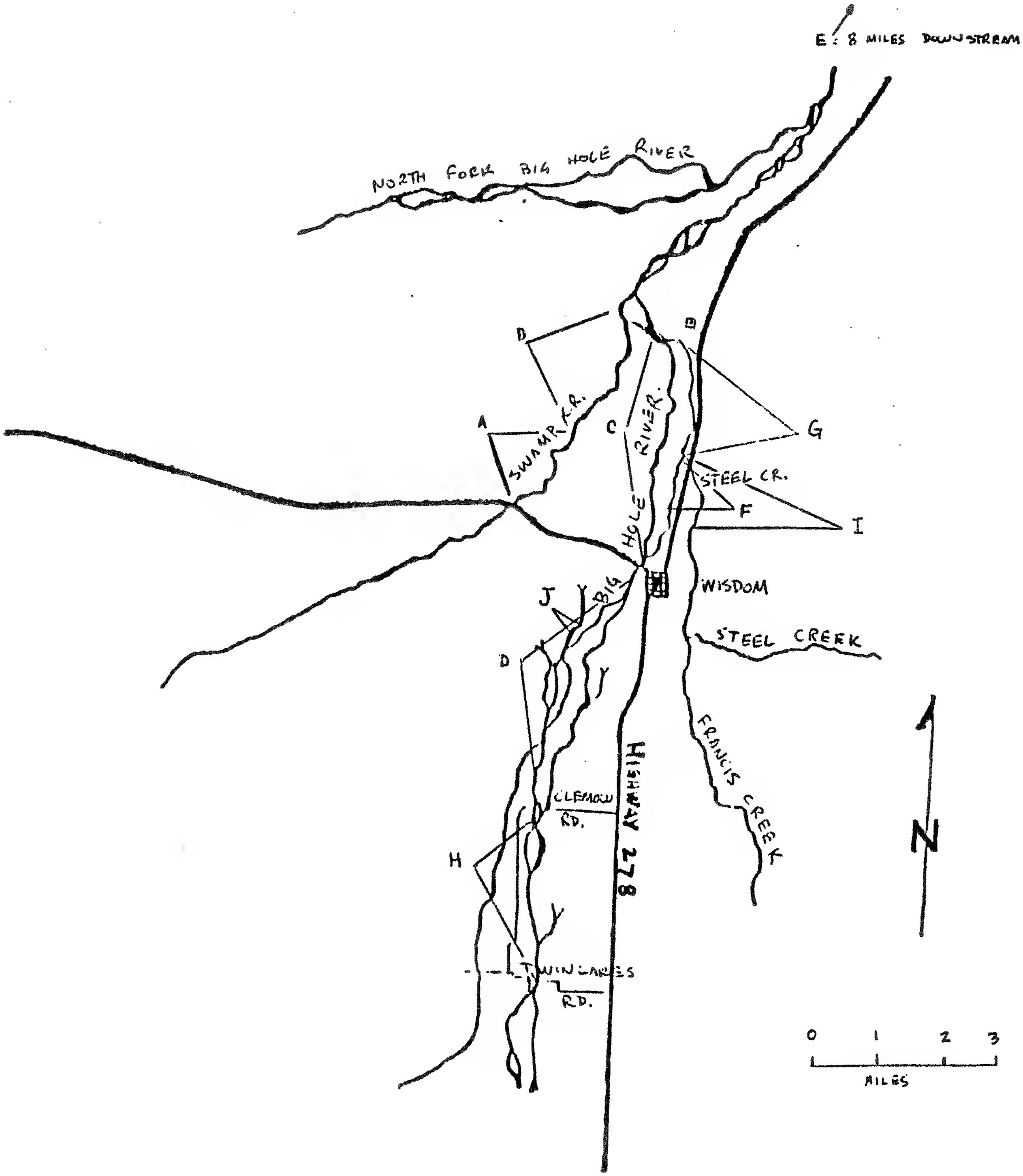


Figure 1. Map of the upper Big Hole River drainage, showing sample sections where electrofishing surveys were conducted.

Table 1. Physical characteristics of sample sections in the upper Big Hole River basin and dates of sampling.

Stream/ Sample Section	Length (miles)	Gradient (%)	Electrofishing Date(s)	Electrofishing Flow (CFS)
Swamp Creek				
A: Upper	~ 2.0	~ .30	6/21	~ 35 (est)
B: Lower	1.9	.28	6/22, 7/6, 7/11, 8/1, 8/2	8-35
Big Hole River				
C: Below Wisdom (West Channel)	3.49	.25	6/26, 7/12, 7/18	26-70
D: Above Wisdom (Clemow-Wisdom)	~ 5.0	.26	6/27, 7/19	15-50 (est)
E: Below Wisdom (Pintlar Cr.-Squaw Cr.)	~ 5.0	<.25	6/28	70 (est)
F: Below Wisdom (Upper East Channel)	~ 1.0	~ .25	7/13	20
G: Below Wisdom (Lower East Channel)	2.83	.27	7/17, 8/3, 8/7-10, 8/14-18, 8/21, 8/28 *	2.5-30
H: Above Wisdom (Twin Lks Rd.-Clemow Rd.)	~ 3.0	~ .25	7/24	25 (est)
Steel Creek				
I: Highway 278-Campground Rd.	1.39	.36	7/26-27	10 (est)
Irrigation Ditch				
J: Cal Erb's Ranch (formerly McDowell's)	.18	.18	7/14, 7/21	2 (est)

* Small sub-sections sampled only on most days.

The backpack system was used primarily in side channels, irrigation ditches and smaller tributaries of the Big Hole River where flows seldom exceeded 15 CFS. Backpack electrofishing proceeded in an upstream direction when data were collected for distribution and relative abundance. Electrofishing proceeded both upstream and downstream while marking locations for later microhabitat measurements. Samplers would move as quietly as possible and stab the electrode in the water in an attempt to avoid displacing the YOY grayling. We immediately marked locations where specimens were captured for later habitat measurements. Different colored rocks were used to differentiate between sites where fish were captured: 1) while backpack shocking upstream, 2) while backpack shocking downstream, or 3) in a grid apparatus. The grid system was used in areas where we had captured large numbers of YOY grayling to try to determine whether the fish captured with each backpacking system had been displaced. The six grids, ranging from three to 12 square feet in size, were typically set in appropriate habitat from 12 to 72 hours before the power supply was turned on. A netter was positioned downstream of the grid (often on the streambank) and remained motionless for 30 seconds to two minutes until the person operating the power supply (either in the boat downstream or on the bank) about 50 feet away supplied power to the grid. The netter then rushed forward and netted the fish as they were stunned in the area inside the grid. If YOY grayling were captured, then each spot was immediately marked with one of the aforementioned colored rocks for later microhabitat measurements.

In addition to Arctic grayling and brook trout, YOY mountain whitefish (Prosopium williamsoni) and rainbow trout (Oncorhynchus mykiss) were netted and placed in a live car until they were measured to the nearest 0.1 inch in total length (TL) and weighed to the nearest 0.01 pound. Lengths and weights were converted to metric units and condition factors (K) were calculated using the following equation:

$$K = \frac{(\text{weight in grams}) \times (100{,}000)}{(\text{length in mm})^3}$$

Macrohabitat parameters were quantified in areas where relatively high numbers of YOY grayling were captured (referred to as "intensive-use areas" by Skaar (1989)) to characterize the general habitat the YOY grayling were using. Four locations were selected as macrohabitat areas on the lower section of the east channel of the Big Hole River (section G) where large numbers of YOY grayling were captured. Transects were established perpendicular to the direction of flow and were spaced from five to 20 feet apart. Depth, velocity, substrate, and cover were quantified at 1.0 foot intervals along each transect except in some isolated backwaters where measurements were taken every 3.0 feet. Depths were measured to the nearest 0.1 foot with a yard stick affixed to a wooden handle and velocities were taken at 0.6 total depth using a type AA flow meter (Price model) and rod. Substrate composition was visually established using the standard size categories of silt (<0.0024 in.), sand (0.0024-0.0787 in.), small gravel (0.0787-0.236 in.), large gravel (0.236-2.52 in.), and cobble (2.52-9.84 in.). No boulders (>9.84 in.) were found in measured areas. Embeddedness was also visually estimated by examining cobbles and large gravel particles at each increment of the transect for the percentage of the particle that was embedded in the fines. Cover types were characterized, if present, at each point along the transect as aquatic vegetation, terrestrial vegetation, soil clump (from eroding streambanks), pool (over 2.0 feet deep), bank, and debris.

Microhabitat measurements were taken from one hour to two weeks following capture under flow conditions that were not different by more than 20%. The area inside of a 3.28 square foot area centered on the capture site was quantified with respect to depth, velocity (at 0.6 depth and bottom), substrate,

embeddedness, cover, distance to cover, and proximity to both upstream and downstream riffles. The capture sites for fish captured while backpack shocking upstream, backpack shocking downstream, and using grids were treated, in most cases, separately in this report to determine whether capture method had an affect on the capture site parameters.

Pocket thermometers were used to measure water temperatures at random locations and times of day to the nearest degree Fahrenheit. Streamflows were measured every other week at each of four gauge stations using the type AA current meter. Gauge heights were recorded at least once each week at each location. Staff gauges were located on Swamp Creek at the bridge on the North Fork of the Big Hole Road (section B), on the west channel of the Big Hole River (on the west bank) approximately 0.3 miles downstream of the Wisdom Bridge (section C), on the upper portion of the east channel of the Big Hole River about 50 yards upstream of the confluence with Steel Creek (section F), and on the lower portion of the east channel of the Big Hole River about 0.75 miles downstream of the confluence with Steel Creek (section G).

To investigate possible competition for food items between brook trout and Arctic grayling stomach samples were collected from 35 brook trout and 12 Arctic grayling using the gastric lavage technique discussed by Light et al. (1983). These samples were then pooled into the following categories: 1)brook trout 6-10" TL, 2)brook trout >10" TL, 3)Arctic grayling 6-10" TL, and 4)Arctic grayling >10" TL. Stomach contents were then sorted into the following classifications with the aid of a dissecting microscope: mayfly, caddisfly, stonefly, scud, aquatic beetle, terrestrial insect, leech, worm, fish, cranefly, and unidentified. Percent composition of the identified matter was calculated for each category (except 'unidentified') by number and volume.

RESULTS AND DISCUSSION

Distribution and Abundance of Fishes

The highest concentrations of YOY Arctic grayling were located in the east channel (Steel Creek channel) of the Big Hole River below the town of Wisdom (section G; Table 2). The highest densities in this area occurred from the confluence of Steel Creek downstream for approximately 2.5 miles. Notable concentrations of YOY grayling were also found in the west channel of the Big Hole River below Wisdom (section C) and in an irrigation ditch on Cal Erb's (formerly McDowell's) ranch just upstream from Wisdom (section J). Relatively few YOY grayling were captured on Swamp Creek (section B), Steel Creek (section I), the Big Hole River upstream of Wisdom (section D), and the upper east channel of the Big Hole River below Wisdom (section F). Age I+ Arctic grayling, though very sparse in general, were most numerous in sections C and G, following a similar pattern of distribution as that of the YOY grayling. No grayling and only 11 brook trout were captured in approximately 5.0 miles of river between Pintlar Creek and Squaw Creek in an area that was severely dewatered during the summer of 1988.

Though not quantified in many cases, the higher densities of YOY grayling were found in similar habitat, and in close association, with YOY mountain whitefish indicating they may exhibit similar habitat preferences during their first summer of life. Young-of-the-year brook trout were most plentiful in Steel Creek (section I) and in the lower section of Swamp Creek (section B). They were also relatively abundant in the lower east channel of the Big Hole River (section G), however the linear densities should be interpreted cautiously as they include multiple samplings in some circumstances which may give a misleading impression overestimating the actual relative density in a given section.

Adult brook trout were most numerous in lower Swamp Creek

(section B) and in the west channel of the Big Hole River below Wisdom (section C). Rainbow trout were very rare throughout the

Table 2. Total number and relative abundance of Arctic Grayling and brook trout captured by electrofishing in the Big Hole River drainage, June 21 - August 28, 1989.

	Number captured (number/1000 ft of stream)*					
	Arctic grayling			brook trout		
Stream/ section	YOY	<9 in	>9 in	YOY	<6 in	>6 in
Swamp Creek:						
A:	0(0)	0(0)	0(0)	0(0)**	17(1.6)	61(5.8)
B:	14(1.4)	9(0.9)	0(0)	100(9.9)	17(1.7)	181(18.0)
Big Hole River:						
C:	100(5.4)	9(0.5)	8(0.4)	2(0.1)	1(.05)	124(6.7)
D:	11(0.4)	0(0)	3(0.1)	3(0.1)	1(.04)	58(2.2)
E:	0(0)	0(0)	0(0)	0(0)	0(0)	11(0.4)
F:	6(1.1)	3(0.6)	0(0)	0(0)	0(0)	5(0.9)
G:	495(33.1)	39(2.6)	5(0.3)	109(7.3)	7(0.5)	67(4.5)
H:	0(0)	1(.06)	0(0)	4(0.3)	0(0)	9(0.6)
Steel Creek:						
I:	6(0.8)	3(0.4)	0(0)	200(27.3)	0(0)	5(0.7)
Irrigation Ditch:						
J:	10(10.0)	0(0)	0(0)	0(0)	0(0)	1(1.0)

* = Several sections were sampled more than once, see Table 1.
** = Sampled prior to the time when YOY brook trout were large enough to be vulnerable to our collection methods.
Note: Number per pass would not be appropriate because passes varied with respect to intensity, method, and duration.

entire study area and were captured in only sections C (1), D (1), E (1), and G (1). Skaar (1989) found higher concentrations of rainbow trout in the Big Hole River and Governor Creek about 15 miles upstream of the 1989 study area and theorized that the rainbow trout present in the Wisdom area had drifted down from this upstream area.

Burbot (Lota lota), longnose dace (Rhinichthys cataractae), longnose suckers (Catostomus platyrhynchus), white suckers (C. commersoni), and mottled sculpin (Cottus bairdi) were captured in differing densities throughout the study area but were not quantified (see Skaar (1989) for relative abundance and distribution of these species).

In most cases the distribution and relative abundance of both Arctic grayling and brook trout in 1989 were very similar to those reported by Skaar (1989) with the notable exception of the lower density of YOY grayling in the lower portion of Swamp Creek. This may have been due in part to the higher discharges present in Swamp Creek in 1989 that may have lowered our capture efficiency for these small fish.

Growth of Young-of-the-Year Fishes

Young-of-the-year Arctic grayling increased in mean total length (TL$\pm$SD) from 2.52 $\pm$ .08 in. on July 6 to 4.08 $\pm$ .24 in. on August 28, 1989 (Table 3, Fig. 2). These lengths are very similar to those found by Skaar (1989) for the same area in 1988 but, as Skaar (1989) pointed out, these are much larger than the lengths reported by Liknes (1981) for YOY grayling in the tributaries of the Big Hole River in 1979. Liknes (1981) reported mean TLs of 2.17 $\pm$ .22 inches for the period of July 11-15, 1979, while Skaar (1989) found that for the period of July 12-14, 1988 the grayling were 2.68 $\pm$ .19 inches in mean TL. For the period of July 11-14, 1989, 80 YOY Arctic grayling sampled in four areas of the Big Hole River showed a mean TL of 2.55 $\pm$ .15 inches. The size differences between these years may be related to water temperatures.

Table 3. Mean and range of total length of YOY Arctic grayling, mountain whitefish, and brook trout in the Big Hole River drainage, July 6 to August 28, 1989.

Date	Grayling Mean (±SD)	Grayling Rng.	Grayling N	Whitefish Mean (±SD)	Whitefish Rng.	Whitefish N	Brook Trout Mean (±SD)	Brook Trout Rng.	Brook Trout N
Jul 6	2.52 (0.08)	2.4-2.6	5	2.63 (0.11)	2.5-2.9	26	2.54 (0.26)	1.9-3.1	85
Jul 11-14	2.55 (0.15)	2.1-3.0	80	2.83 (0.23)	2.3-3.0	9	---	---	---
Jul 17-20	2.80 (0.19)	2.4-3.2	101	2.92 (0.24)	2.4-3.6	39	2.66 (0.41)	2.1-4.5	33
Jul 21-24	2.69 (0.19)	2.3-3.0	9	3.35 (0.19)	3.0-3.6	17	2.63 (0.05)	2.6-2.7	4
Jul 26-27	3.06 (0.15)	2.9-3.2	5	---	---	---	2.73 (0.66)	1.7-4.6	67
Aug 1-3	3.42 (0.18)	3.0-3.8	203	3.43 (0.22)	2.9-4.1	60	3.11 (0.22)	2.7-3.6	25
Aug 7-10	3.68 (0.19)	3.0-4.1	144	3.49 (0.19)	3.0-3.8	52	3.11 (0.41)	2.2-3.9	58
Aug 14-16	3.70 (0.22)	3.3-4.1	19	3.53 (0.25)	3.0-3.9	12	---	---	---
Aug 17-21	3.90 (0.28)	3.3-4.4	33	3.64 (0.33)	3.1-4.0	7	3.40 (0.22)	3.0-3.5	5
Aug 28	4.08 (0.24)	3.7-4.7	55	3.69 (0.19)	3.2-4.1	33	3.71 (0.16)	3.5-4.0	8

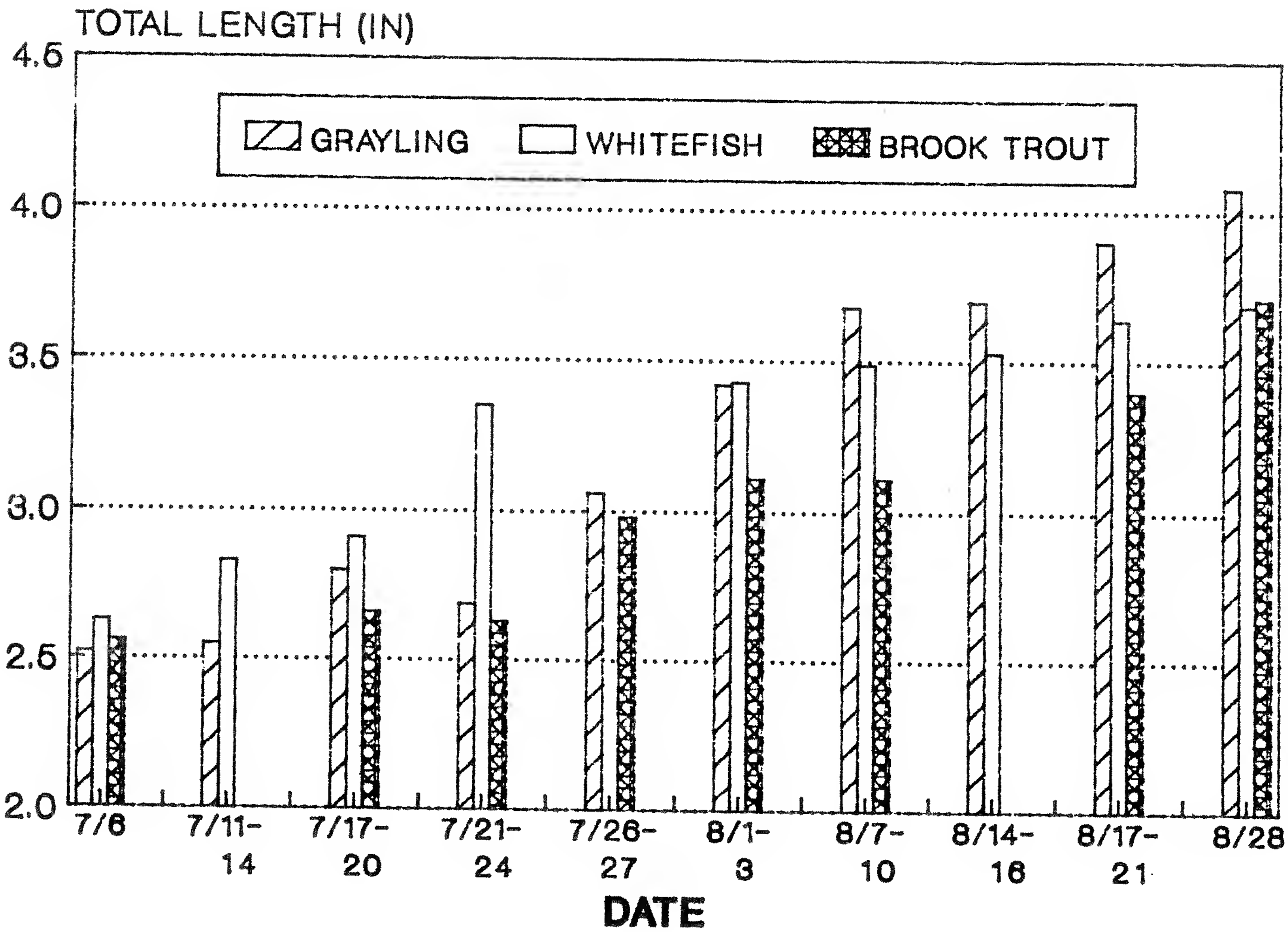


Figure 2. Mean length of young-of-the-year Arctic grayling (N=654), mountain whitefish (N=255), and brook trout (N=285) versus date for the Big Hole River and its tributaries, July 6 to August 28, 1989.

Mountain whitefish appeared to grow more rapidly than either grayling or brook trout between July 6 and 24, after which grayling grew more rapidly and surpassed whitefish in mean TL. Young-of-the-year brook trout grew relatively slowly and showed a greater variation (some very small age I+ may have erroneously been included in the calculation of YOY mean TL). Skaar (1989) reported very similar growth rates for both Arctic grayling and brook trout in these waters during the summer of 1988.

Condition factors (K) were calculated for 46 age I+ Arctic grayling captured during July and August, 1989 in the study area for comparison with the condition factors reported for the same waters by Liknes (1981) for 1979 and by Skaar (1989) for 1988. For grayling between 6.4 and 13 inches TL the mean K value ($\pm$SD) was 1.10 ($\pm$.20). This was higher (the fish were in better condition) than those measured by either Liknes (1981) [K=0.95 $\pm$.08] or Skaar (1989) [K=1.06 $\pm$.11]. Flows were slightly higher and temperatures were slightly cooler during the summer of 1989 than they were during the same period of 1988 which may help explain the healthier individual fish. One could also speculate that with the much reduced densities of age I+ grayling since 1979, the grayling that survive to age I have considerably less competition for food and space, if food and space are limiting.

Habitat Utilization by Young-of-the-Year Arctic Grayling

Macrohabitat Utilization

The east channel of the Big Hole River (section G) was chosen for habitat measurements due to the high densities of YOY Arctic grayling found there. Four areas were intensively measured with respect to depth, velocity, substrate, and cover to develop an index of availability for these parameters in an attempt to determine whether YOY grayling were selecting habitat types in proportion to their occurrence.

Seventeen YOY grayling were captured in macrohabitat area 1 (Fig. 3) which was located approximately 200 feet upstream of the 'intensive-use area C' described in Skaar (1989) and was in an

area marked by two orange-colored 'spawning flags' which were placed by MDFWP personnel at locations where adult spawning grayling were captured during electrofishing in late April and May, 1989. The presence of large concentrations of YOY grayling in areas where spawning grayling were captured suggests a high site fidelity of YOY grayling to the areas in which they were spawned.

Area 2 (a and b) (Figs. 4 and 5) consisted of one long riffle-pool-riffle sequence and was located approximately 500 yards upstream of area 1. Area 3 (Fig. 6) was actually the downstream end of a very long riffle-run-pool-riffle complex of which area 4 (Fig. 7) was the upstream portion. These are presented primarily to show the location of YOY grayling capture sites that resulted from the downstream run with the backpack shocker. Most of these fish were captured in a small sidewater pocket immediately upstream of a shallow riffle. Though herding was not directly observed in this case, it seems likely that the fish were driven from the pool-run habitat upstream of the capture sites. No YOY grayling were captured with either the grids or the backpack shocker while moving in an upstream direction in this general area. Area 4 was upstream of, and separated from, area 3 by a 140 foot long shallow run. There were no YOY grayling collected in this run area, as the grayling were probably driven out while the electrofishers were walking through the area. Grids set in this shallow run also yielded no YOY grayling. The upper boundary of area 4 was located on a riffle that adult grayling may have spawned on during the Spring of 1989, however no 'spawning flag' was visible in the area (livestock in this area had eaten or displaced many of our flagging markers and may have made the 'spawning flags' less visible).

Typically, the fish captured while electrofishing in an upstream direction were concentrated in areas that: 1) provided some type of cover, and 2) acted in some way as a visual barrier to further upstream movement. These areas were usually

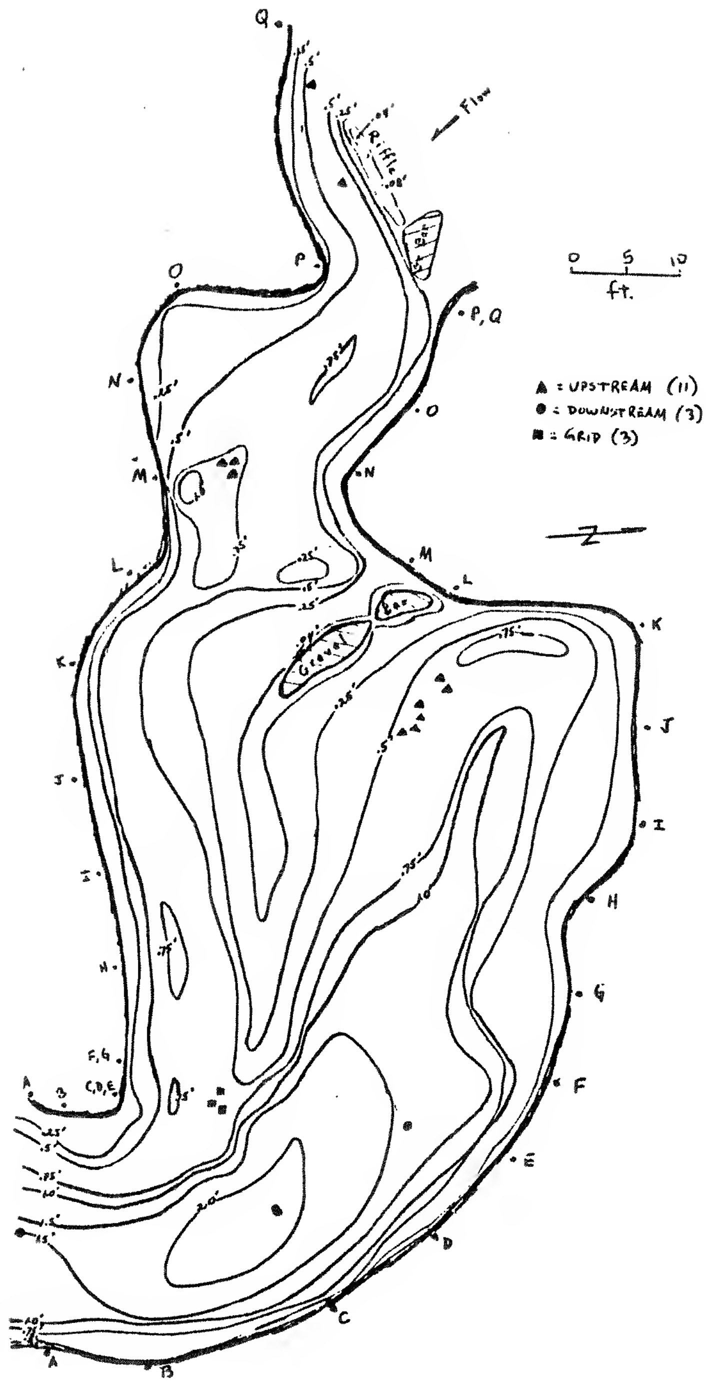


Figure 3. Depth (ft) isopleths for macrohabitat area 1 on the lower east channel of the Big Hole River below Wisdom. YOY grayling that were captured while moving upstream, moving downstream, and in the grids are marked by triangles (▲), circles (●), and squares (■), respectively. Letters along streambanks denote transect points.

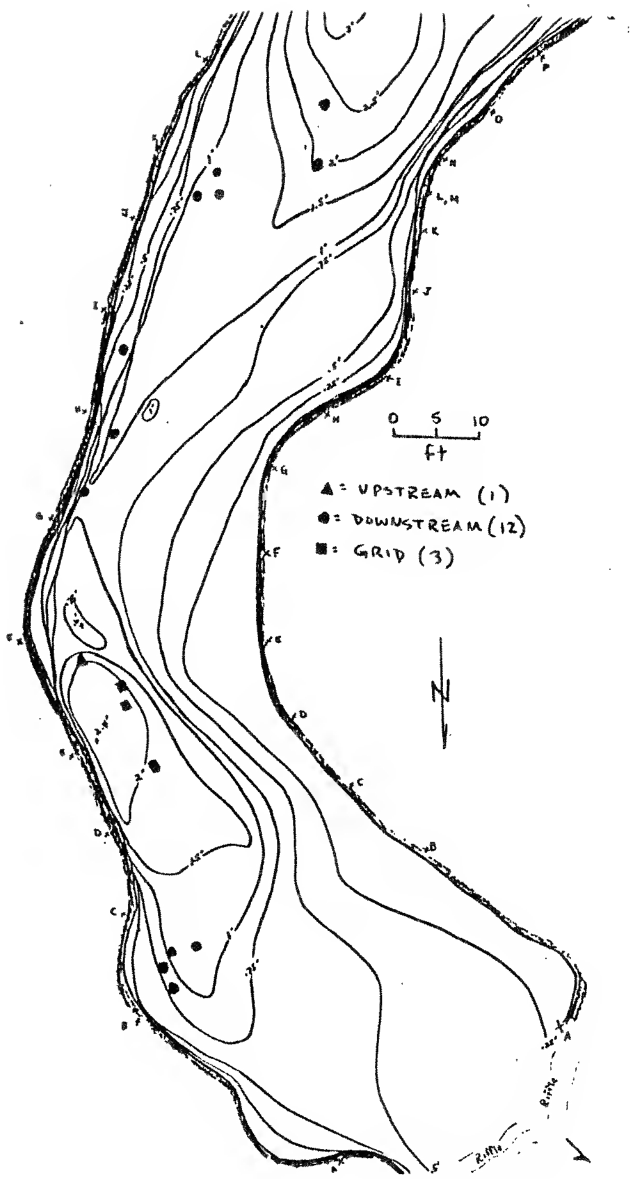


Figure 4. Depth (ft) isopleths for macrohabitat area 2a (lower portion) on the lower east channel of the Big Hole River below Wisdom. YOY grayling that were captured while moving upstream, moving downstream, and in grids are marked by triangles (▲), circles (●), and squares (■), respectively. Letters on streambanks denote transect points.

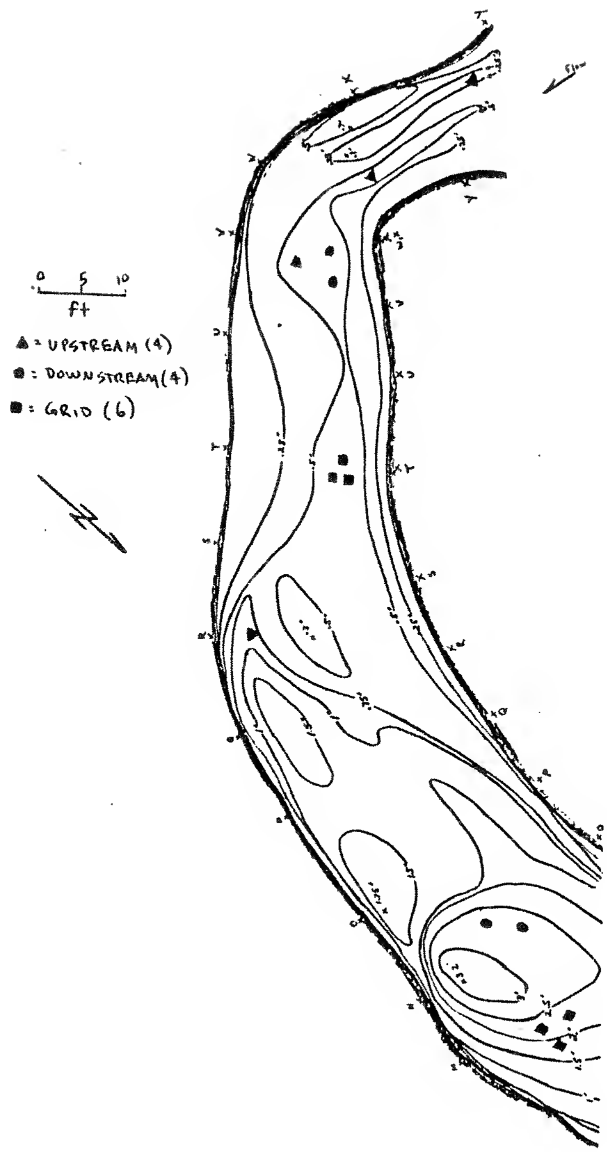


Figure 5. Depth (ft) isopleths for macrohabitat area 2b (upper portion) on the lower east channel of the Big Hole River below Wisdom. YOY grayling that were captured while moving upstream, moving downstream, and in grids are marked by triangles (▲), circles (●), and squares (■), respectively. Letters on streambanks denote transect points.

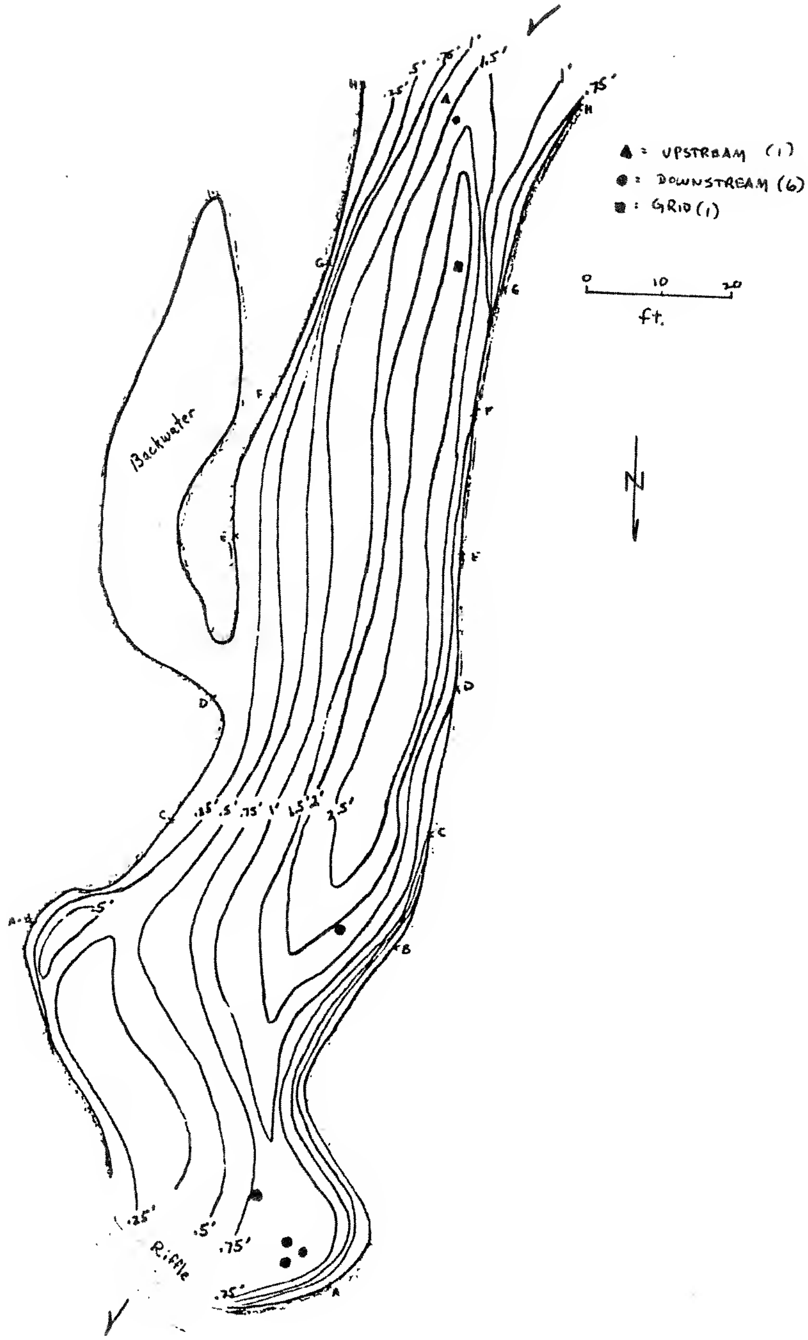


Figure 6. Depth (ft) isopleths for macrohabitat area 3 on the lower east channel of the Big Hole River below Wisdom. YOY grayling that were captured while moving upstream, moving downstream, and in grids are marked by triangles (▲), circles (●), and squares (■), respectively. Letters on streambanks denote transect points.

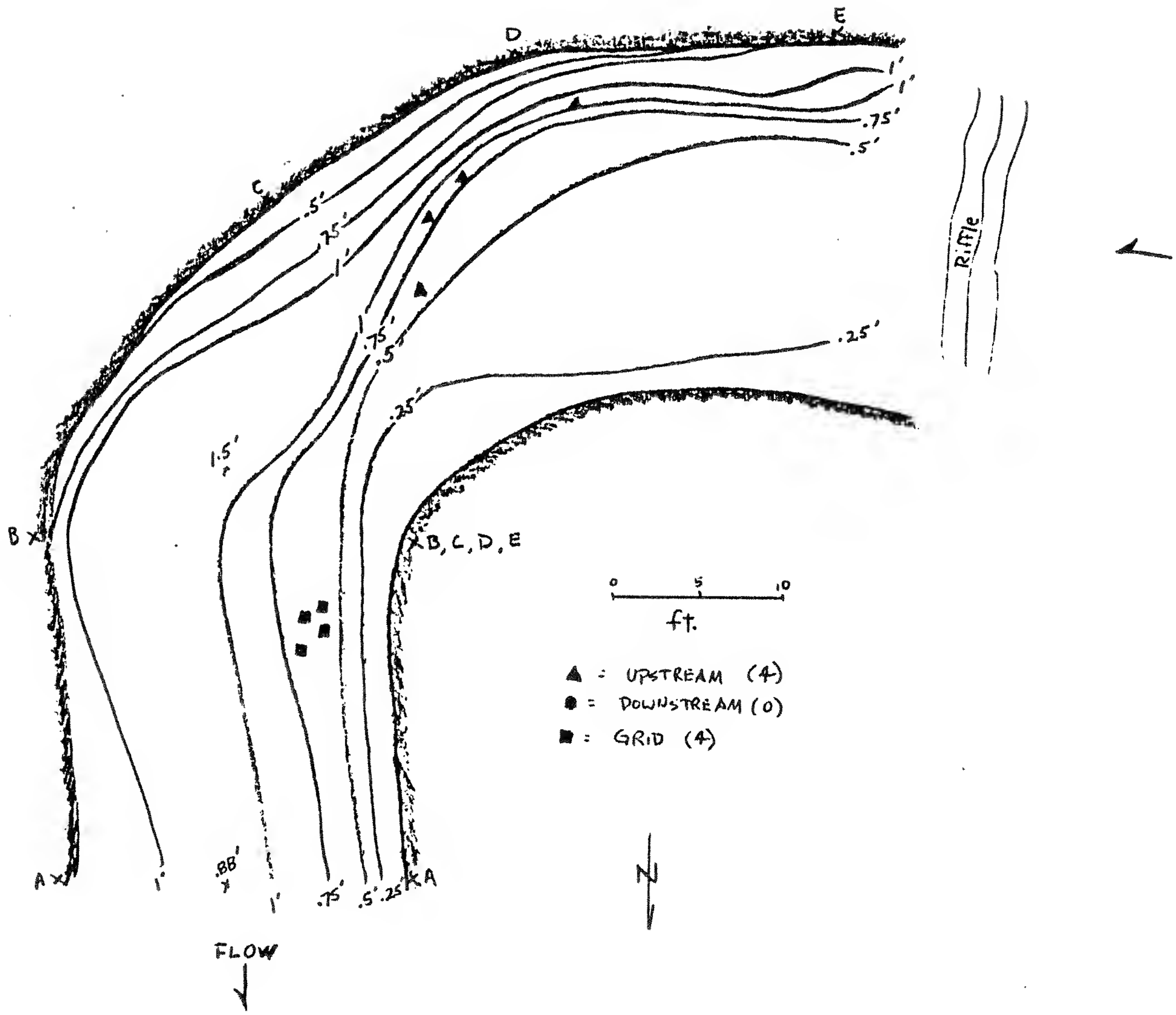


Figure 7. Depth (ft) isopleths for macrohabitat area 4 on the lower east channel of the Big Hole River below Wisdom. YOY grayling captured while moving upstream, moving downstream, and in grids are marked by triangles (▲), circles (●), and squares (■), respectively. Letters on streambanks denote transect points.

depressions in the streambed immediately below a shallow riffle. These types of capture sites indicate that these fish may have been 'herded' upstream into these areas from habitat they actually preferred. In similar fashion, fish captured while electrofishing downstream tended to be concentrated in areas that provided them with cover and occasionally that served as some sort of visual barrier to further downstream movement. Whether the shallow riffles were actually visual barriers, or whether the grayling did not feel secure crossing them is not known, but they rarely would move through these riffle areas.

For 33 YOY grayling captured in grids, the mean distance to the nearest upstream riffle was 74.5 ft, while the mean for the fish collected while electrofishing upstream (sample of 35) was only 39.2 ft (Table 4). The YOY grayling collected while moving downstream (sample of 42) were an average of 158.5 ft below the nearest upstream riffle. A similar, though inverse, relationship is seen in the values presented for the distances above the nearest downstream riffle, the grid fish are intermediate in distance while the fish collected while moving downstream are closest and the fish collected while moving upstream are furthest from the downstream riffle. This indicates that these YOY grayling may have been displaced by the presence and movement of the electrofishers and that the grid method may provide more accurate results with respect to microhabitat information.

The typical macrohabitat area parameters that appeared in all 'intensive-use areas' were, 1) a sloughing outside bank, providing soil clumps of varying size and age, 2) at least one pool area with depths in excess of 1.5 ft, 3) presence of extensive mats of aquatic vegetation, 4) proximity to a riffle with relatively loose substrate particles that may have served as spawning habitat for adult grayling, and 5) streambanks.

Table 4. Habitat features for YOY grayling collected in grids (N=33), electrofishing upstream (N=35), electrofishing downstream (N=42), and macrohabitat in adjacent areas (N=1311) on the east channel of the Big Hole River below Wisdom, August, 1989.

Variable	Grid Mean	Grid Rng.	Upstream Mean	Upstream Rng.	Downstream Mean	Downstream Rng.	Macrohab. Mean	Macrohab. Rng.
Depth (ft)	1.32	.54-2.58	.98	.38-1.67	1.10	.42-2.08	.83	0.0-3.10
Mean Vel (ft/s)	.78	.10-1.84	.59	0.0-2.18	.32	0.0-1.50	.29	0.0-2.35
Bottom Vel (ft/s)	.56	0.0-1.50	.46	0.0-1.80	.27	0.0-1.47	---	---
Dist to Cover (ft)	1.02	0.0-6.50	1.16	0.0-4.00	1.43	0.0-4.50	---	---
Embeddedness (%)	40.75	20-70	52.43	25-100	44.16	20-75	69.45	20-100
Substrate								
Silt (%)	8.33	5-30	13.86	5-50	18.45	5-50	27.86	0-100
Sand (%)	14.54	5-60	30.71	5-80	19.76	5-70	28.51	0-100
Small Grav (%)	12.58	5-30	11.86	0-50	12.38	5-30	8.72	0-100
Large Grav (%)	34.39	5-70	30.57	0-65	31.54	5-65	27.37	0-100
Cobble (%)	30.15	0-60	13.00	0-40	17.62	0-55	6.87	0-100
Dist to Upstream Riffle (ft)	74.47	8-215	39.24	5-201	158.48	16-321	___	___
Dist to Downstrm Riffle (ft)	159.59	56-261	191.08	15-375	85.79	10-300	---	---

supporting permanent perennial grasses and sedges. Mean depth and velocity for the macrohabitat areas were 0.83 ft and 0.29 ft/s, respectively. These mean depths and velocities are slightly less than the means for these parameters measured at the capture sites.

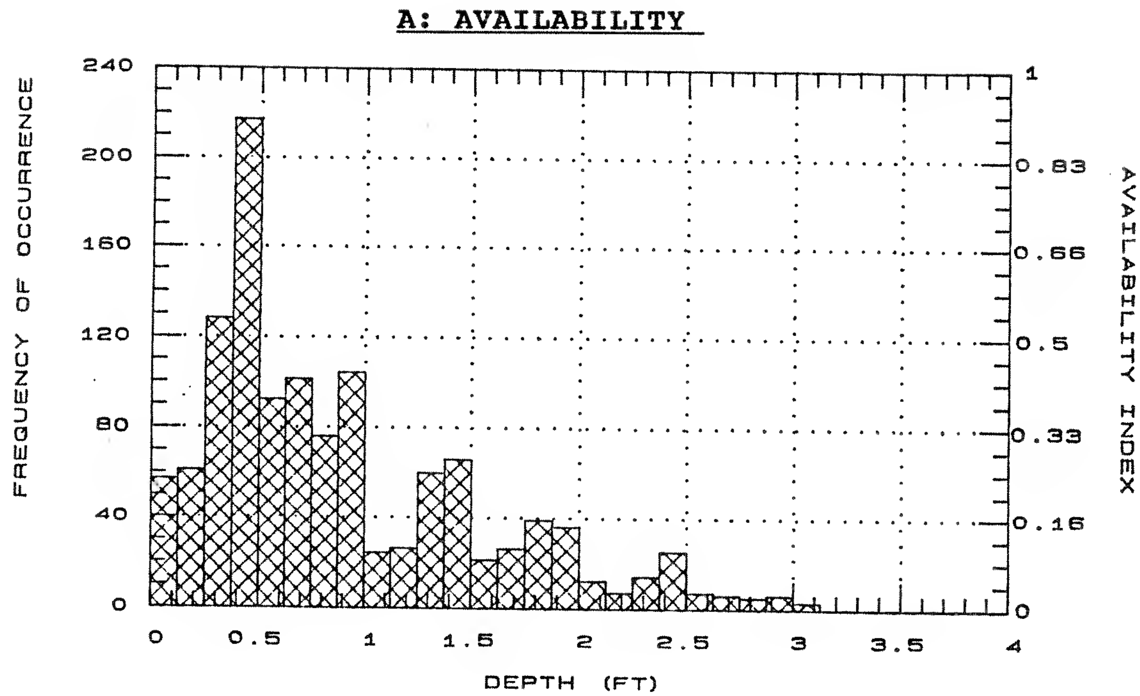
Microhabitat Utilization

Depth and Velocity

Habitat preference is exhibited when fish utilize a particular habitat variable with greater frequency than it is available (Bovee 1986). Young-of-the-year Arctic grayling utilized deeper areas of the Big Hole River with a frequency slightly higher than availability (Figs. 8 and 9). They also selected higher velocity areas (Figs. 10 and 11). Availability was determined by measuring at 1,311 points along transects in macrohabitat areas. Since these areas may have been of higher quality and of different composition than in unused surrounding macrohabitat areas, these determinations of preference may be inaccurate. Random sections of stream were not measured to develop a true index of availability.

Cover

The average distance from a capture site to the nearest cover for grid-captured YOY grayling was 1.02 ft. Aquatic vegetation was the cover type closest to 80% of these sites (Tables 4 and 5). Skaar (1989) reported similar findings for these measures of 0.92 ft and 86%, respectively. Rannunculus aquatilis and Elodea canadensis were the primary species of aquatic vegetation (Skaar 1989). Other cover frequencies were also similar to those reported for the same area in 1988 by Skaar (1989). Aquatic vegetation and soil clumps were utilized in slightly higher proportion than they occurred, while pools were utilized in slightly lower proportion than they occurred. Debris, terrestrial vegetation, and banks were used in approximate proportion to their occurrence.



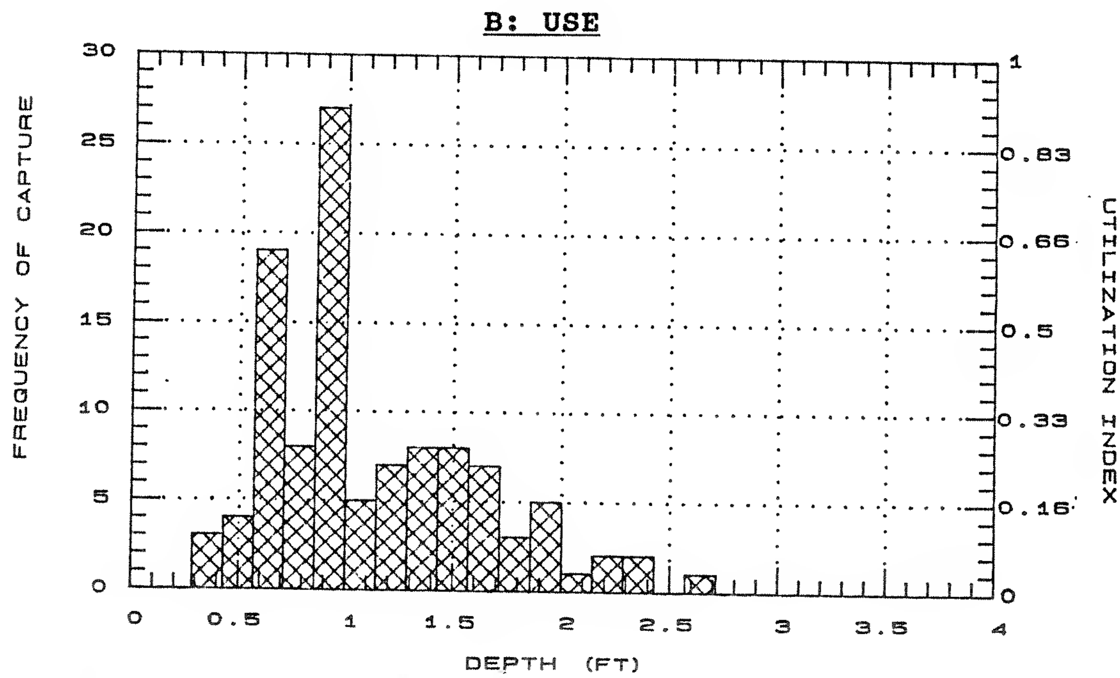


Figure 8. A. Frequency of depth measurements in macrohabitat areas of young-of-the-year Arctic grayling in the Big Hole River.

B. Frequency of depth measurements at capture sites of young-of-the-year Arctic grayling in the Big Hole River.

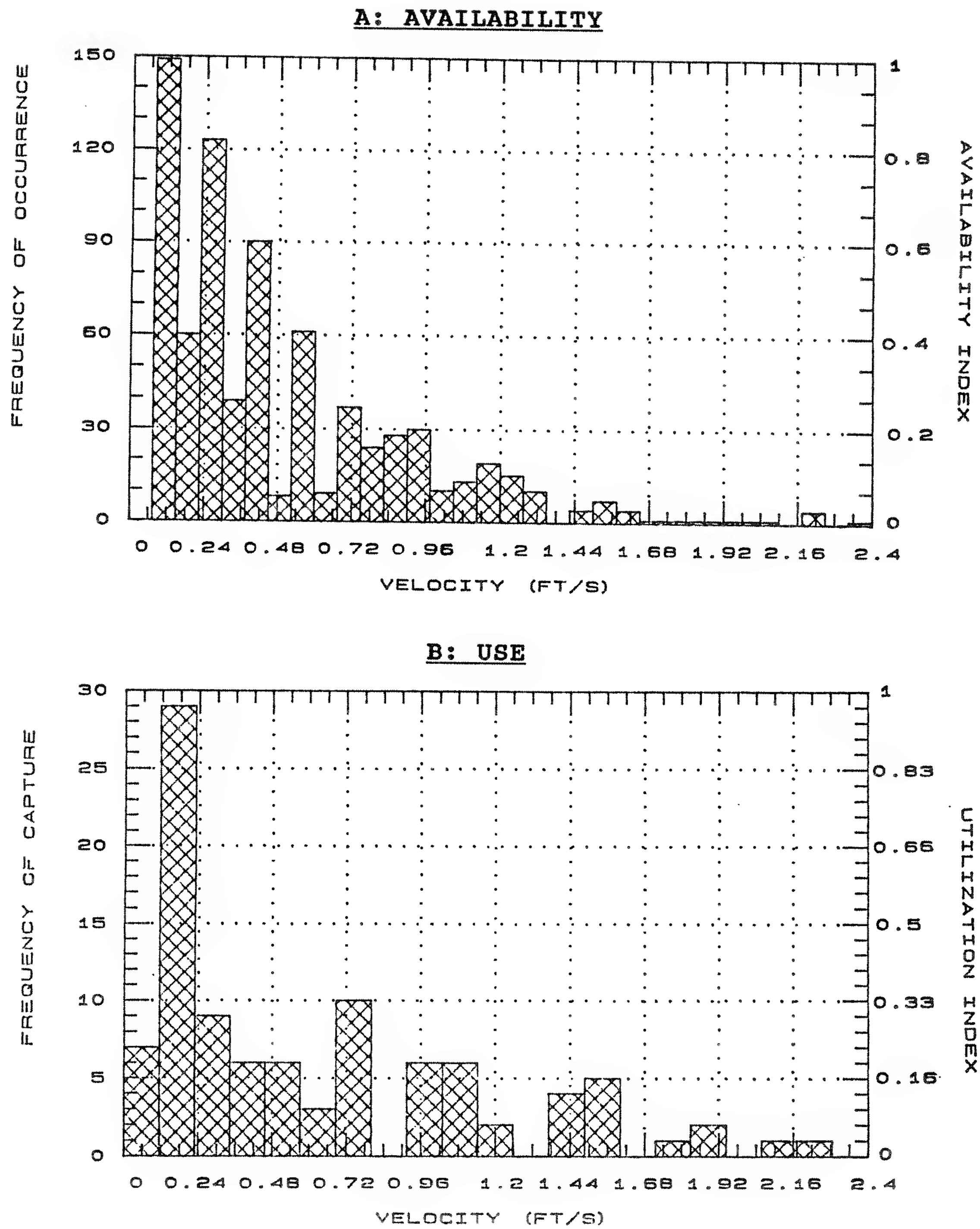


Figure 9. A. Frequency of mean velocities for macrohabitat areas of young-of-the-year Arctic grayling in the Big Hole River.

B. Frequency of mean velocities at capture sites of young-of-the-year Arctic grayling in the Big Hole River.

Table 5. Frequency of cover types within a 3.28 square foot area centered where young-of-the-year Arctic grayling were captured with electrofishing grids and of cover types within the larger macrohabitat areas on the Big Hole River.

Cover Type	Capture Sites (%) (Use)	Macrohabitat (%) (Availability)
Aquatic Vegetation	80	75
Pool	11	19
Soil Clump	4	1
Debris	1	2
Terrestrial Veg.	1	1
Bank	2	1

Substrate

Silt comprised 27.86% of the substrate materials in the macrohabitat areas and only 8.33% in grid-capture sites (Table 4). Embeddedness was lower and the percent substrate composition made up by larger particles (large gravel and cobble) was higher at grid-capture sites than in the adjacent macrohabitat areas, indicating a possible preference for clean substrate with larger particles.

Temperature

Stream temperatures were only randomly recorded and were not always taken when the water temperature was at its daily maximum, therefore the data in Table 6 are presented only to provide a very general thermal trend through time. The highest maximum daily water temperatures occurred from the end of July through the first week of August and appear to be lower, in general, than temperatures recorded in the same area in 1988 (Skaar 1989). No thermally induced mortality was observed.

Table 6. Maximum daily water temperatures recorded on the Big Hole River and its tributaries, June 26 to August 22, 1989. Temperatures from a USGS station at the Wisdom Bridge are shown in brackets (only data available at press time was for June 1989).

Date	Time	Sample Section	Temperature (F)
June 26	1900	C	64 [64.4]
June 28	1425	E	64 [68.4]
July 11	1200	B	63
July 12	1505	C	70
July 13	1230	F	64
July 17	1645	G	64
July 18	1410	C	66
July 19	1345	D	70
July 24	1255	H	68
July 25	1420	F	68
July 26	1200	I	72
August 1	1230	B	65
August 3	1435	G	67
August 7	1345	G	68
August 8	1415	B	72
August 9	1645	G	75
August 21	1530	G	60
August 22	1513	G	66

Flows

Streamflow discharges were much higher in the upper Big Hole River drainage during the summer of 1989 than they were the previous summer. Figures 12 through 15 present the range of flows recorded at each of four staff gauge sites with 95% confidence limits.

Stomach Content Analysis

Arctic grayling in the Big Hole River and its tributaries appear to select different types of food items than the brook trout in the same areas during the summer months. Grayling between 6 and 10 inches (N=9) had stomach contents consisting of 32% mayflies by volume while brook trout of the same size (N=30) showed 23% of their contents to be made up of a variety of fish (Fig. 16). Grayling also tended to utilize other organisms present on the water surface, such as stonefly adults and terrestrial insects, in much greater proportion than did brook trout. Larger grayling (>10") (N=3) showed a more dramatic preference for surface food items (adult mayflies, caddisflies, stoneflies, and terrestrial insects) than did similarly sized brook trout (N=5; Fig. 17). Subsurface food items such as fish, leeches, and cranefly larva comprised the majority of the diets of larger brook trout.

Arctic grayling in the upper Big Hole River drainage seem to show a strong preference for surface food items while brook trout consume a larger proportion of subsurface items, indicating that there may be little direct competition for food between the two species during the summer months. This situation may change considerably during the winter months when surface food items probably become less available. Of the fish found in stomachs of brook trout none could be positively identified as grayling fry or YOY. The majority of the fish present in the stomach samples

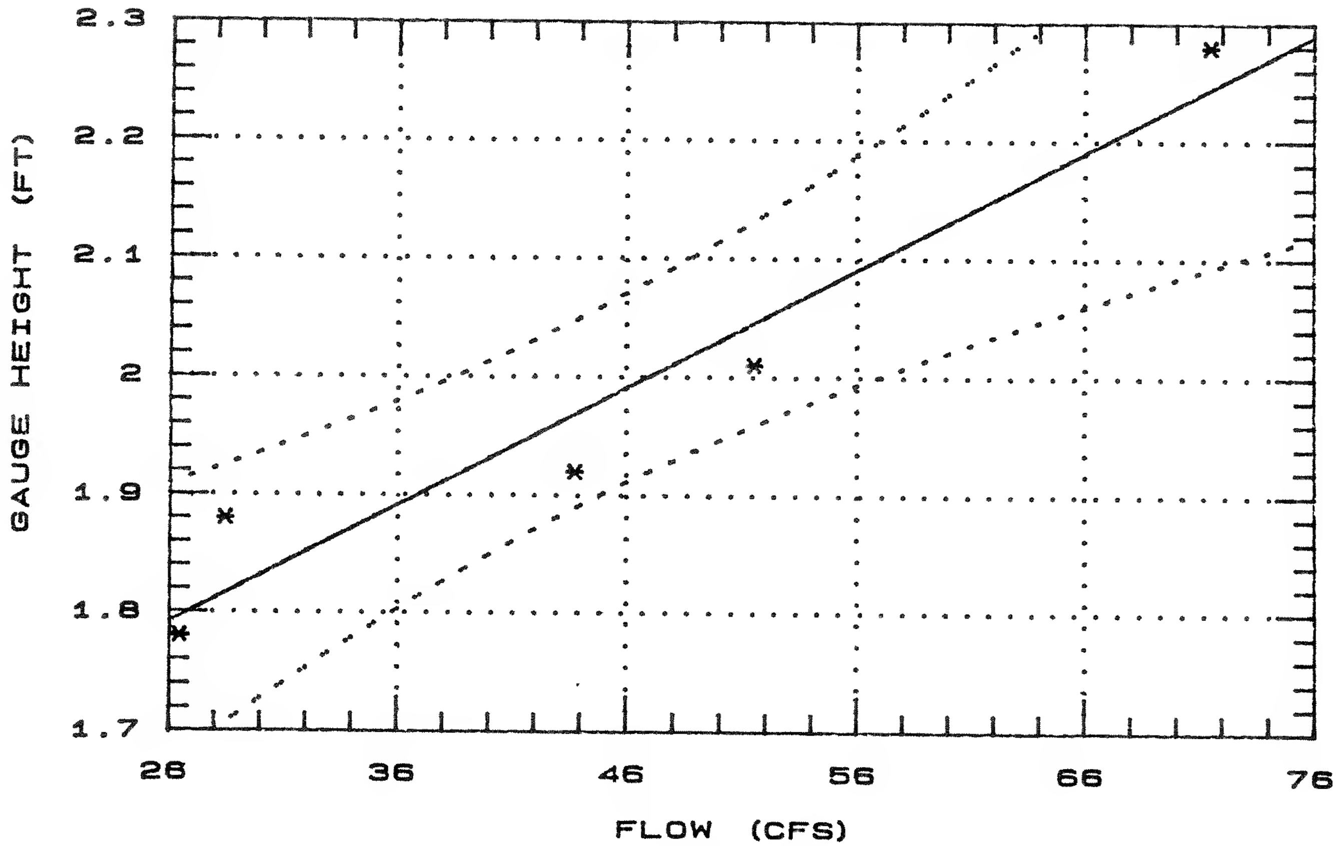


Figure 10. Gauge height (ft) versus streamflow discharge (CFS) for the west channel of the Big Hole River below Wisdom. Dashed lines represent 95% confidence limits.

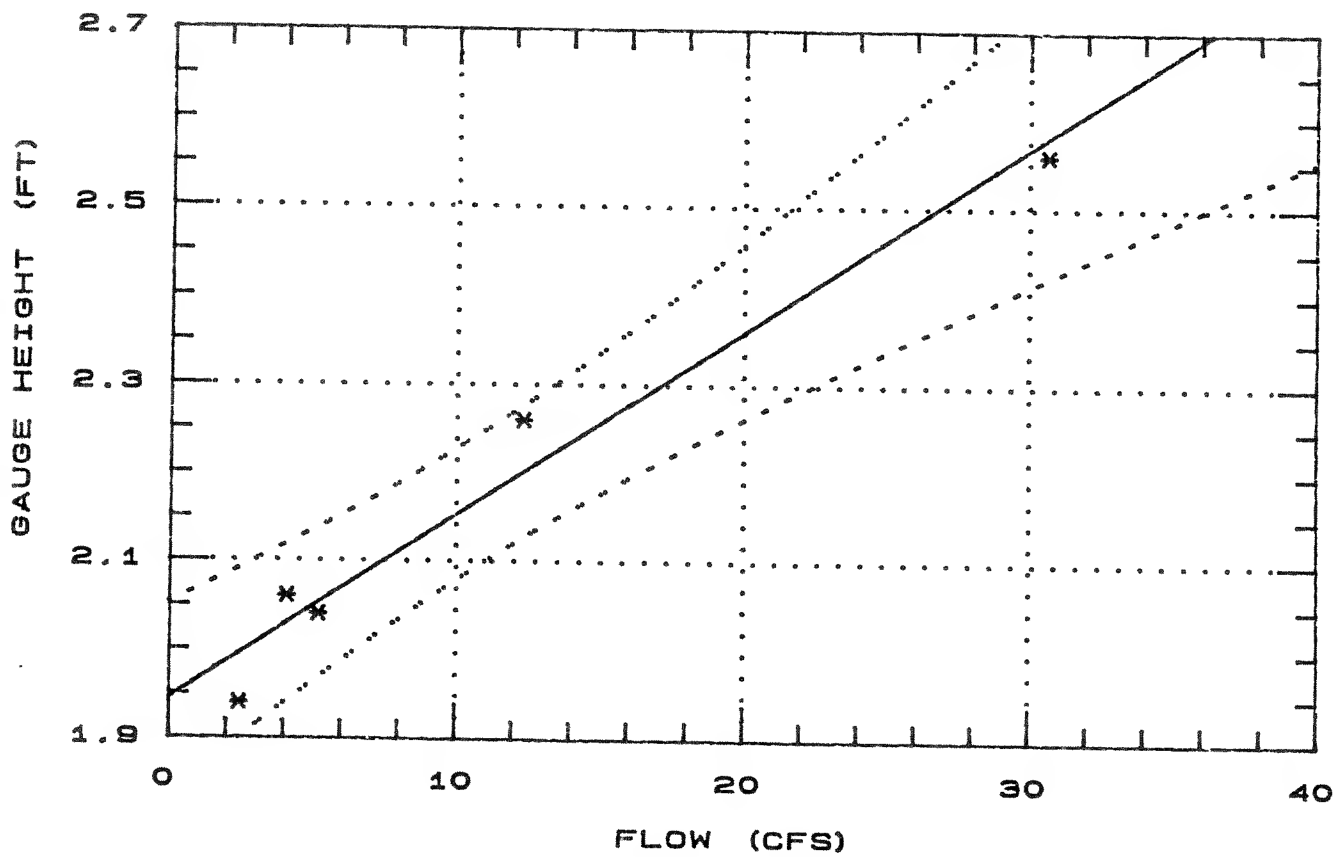


Figure 11. Gauge height (ft) versus streamflow discharge (CFS) for the east channel of the Big Hole River immediately upstream of the mouth of Steel Creek. Dashed lines represent 95% confidence limits.

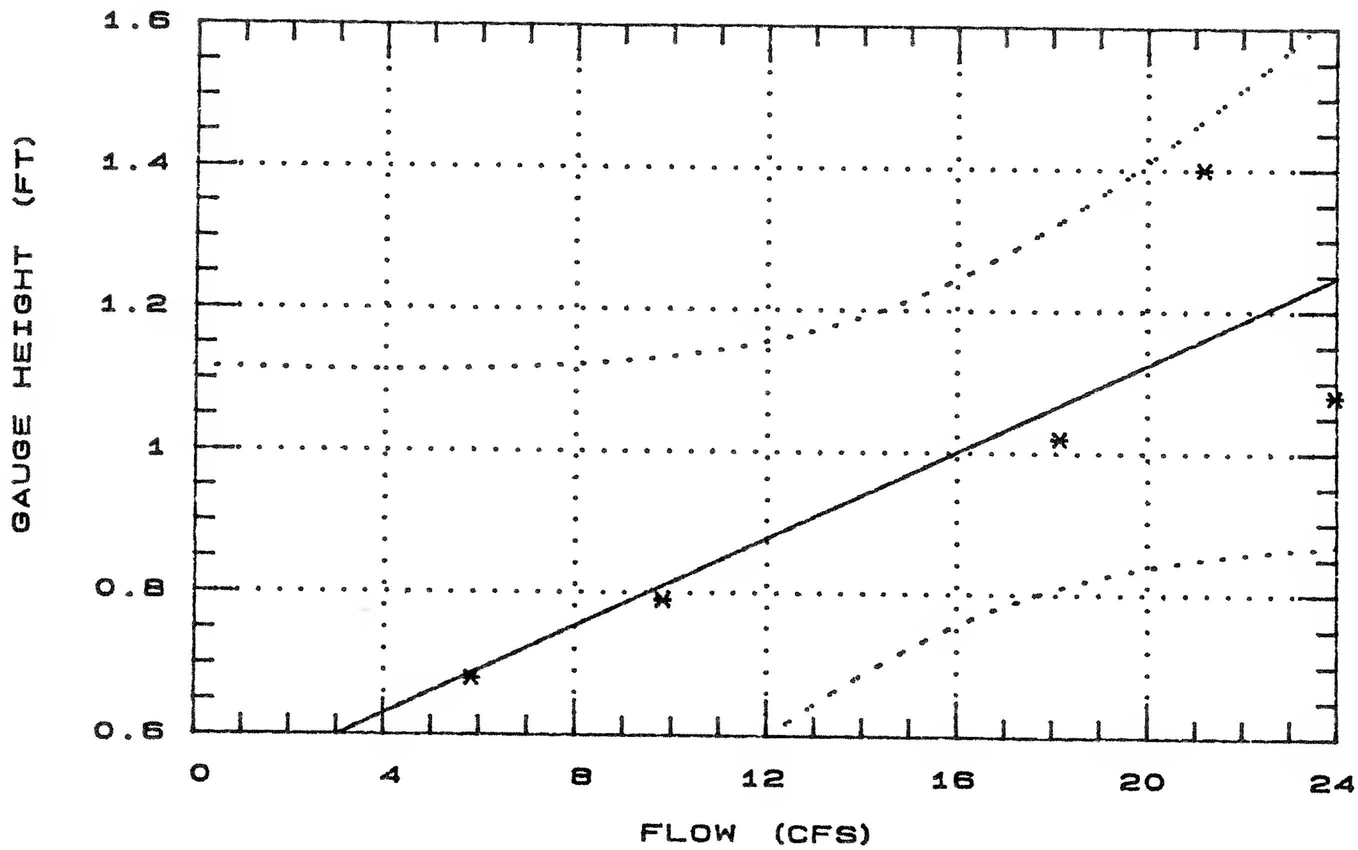


Figure 12. Gauge height (ft) versus streamflow discharge (CFS) for the east channel of the Big Hole River below the mouth of Steel Creek. Dashed lines represent 95% confidence limits.

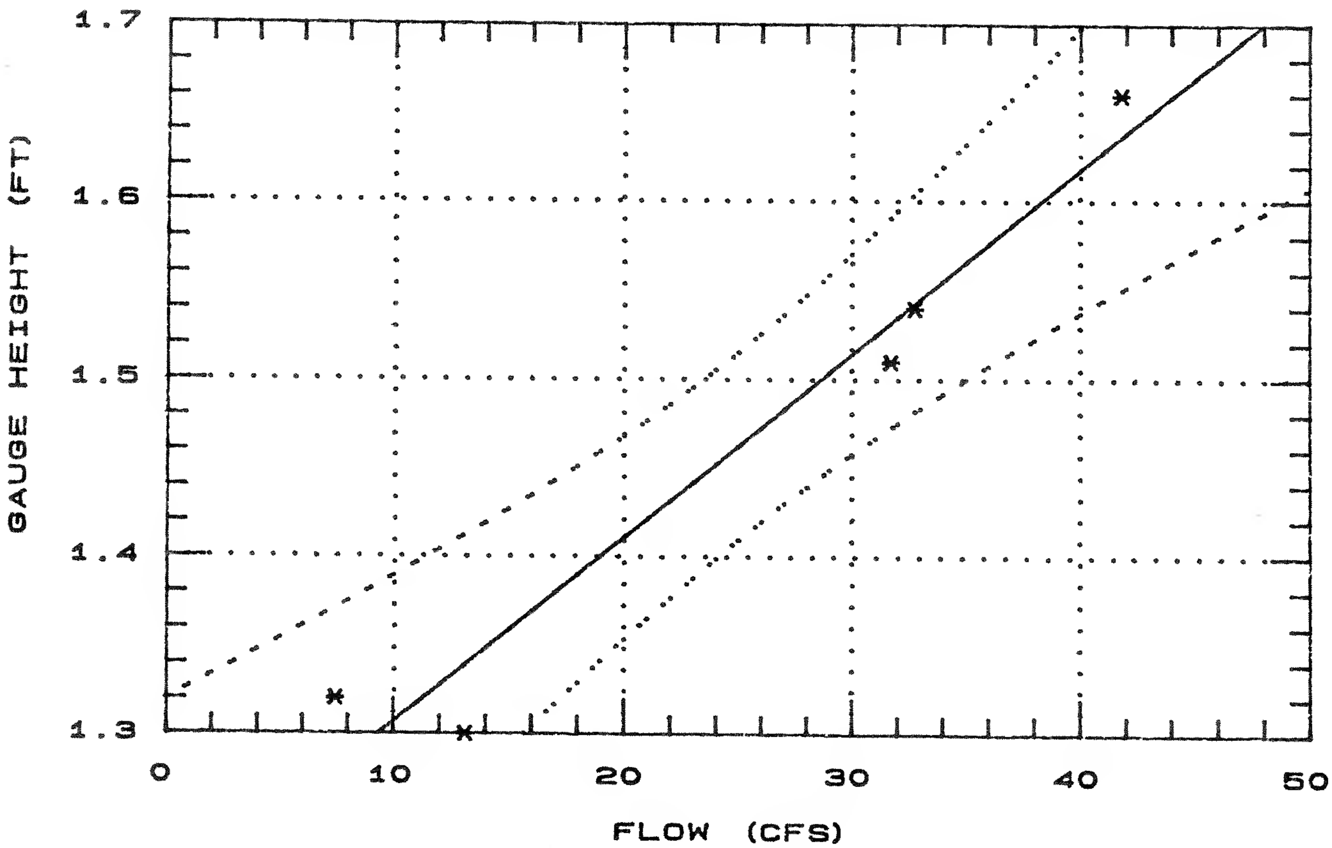


Figure 13. Gauge height (ft) versus streamflow discharge (CFS) for Swamp Creek at the North Fork Road Bridge. Dashed lines represent 95% confidence limits.

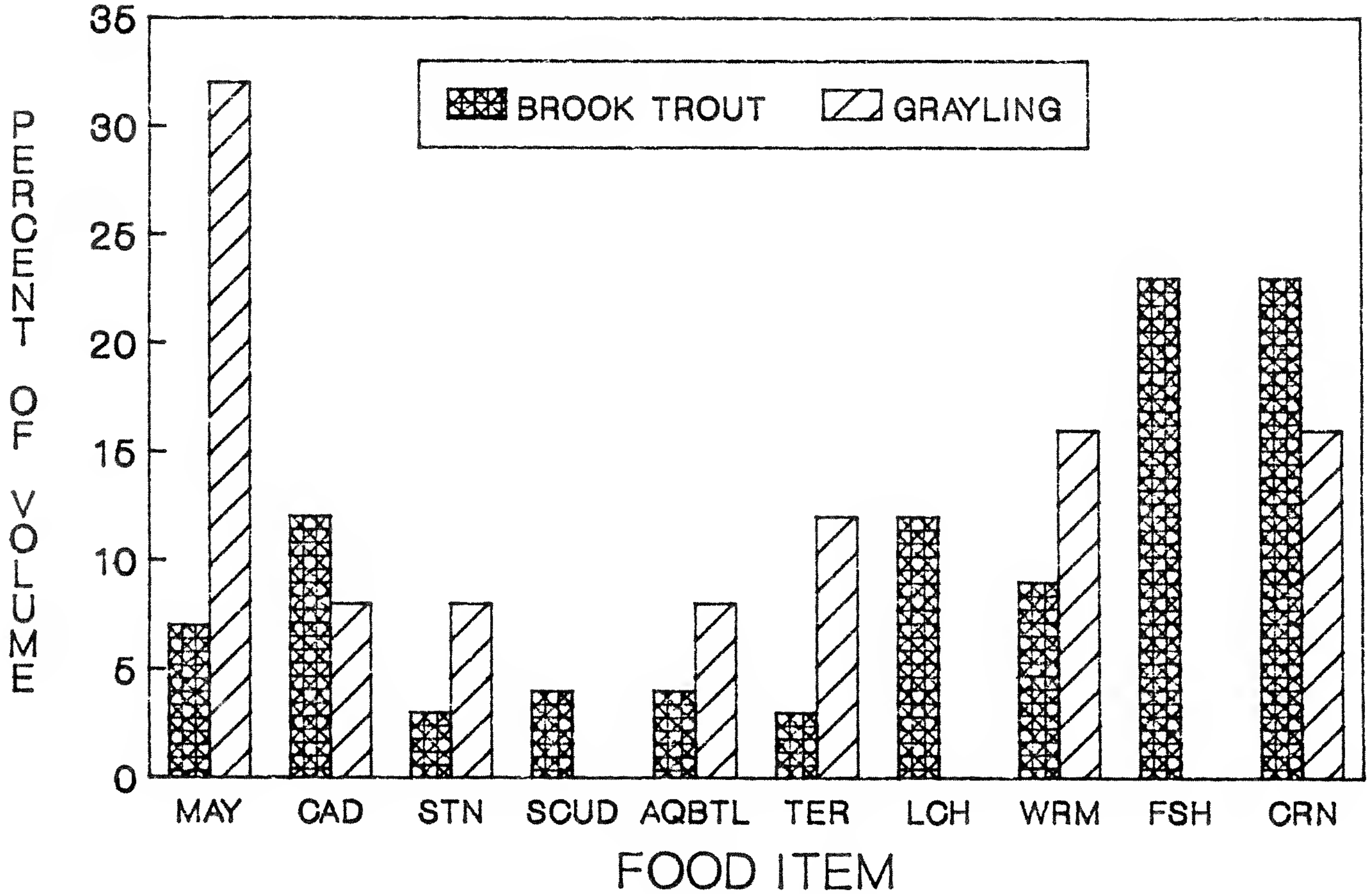


Figure 14. Percent volume of stomach contents of 6 to 10 inch Arctic grayling and brook trout from the Big Hole River and its tributaries made up of various food items.

MAY=Mayfly, CAD= Caddisfly, STN=Stonefly, SCUD=Amphipod Crustacean, AQBTL=Aquatic Beetle, TER=Terrestrial Insect, LCH=Leech, WRM=Worm, FSH=Fish, CRN=Cranefly

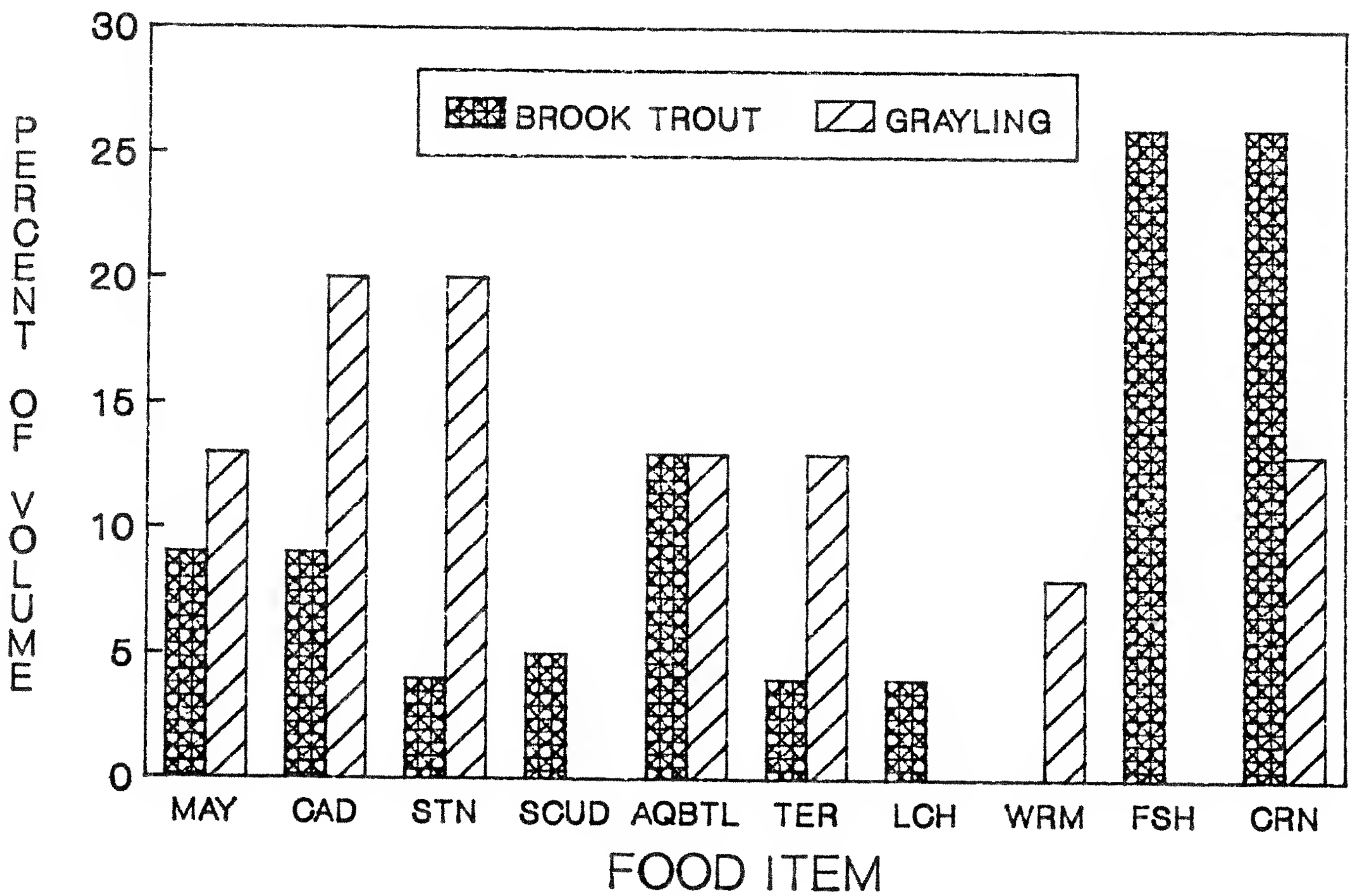


Figure 15. Percent volume of stomach contents of 10 inch and larger Arctic grayling and brook trout from the Big Hole River and its tributaries made up of various food items.

MAY=Mayfly, CAD=Caddisfly, STN=Stonefly, SCUD=Amphipod Crustacean, AQBTL=Aquatic Beetle, TER=Terrestrial Insect, LCH= Leech, WRM=Worm, FSH=Fish, CRN=Cranefly

of brook trout were, in approximate order of abundance, sucker fry, adult longnose dace, and YOY mountain whitefish. Though brook trout predation on grayling fry has been documented (Nelson 1954), it was not seen in any of the samples collected in this study. The stomach pumping portion of this study began when the YOY grayling were approximately 2.5 inches long, which may be beyond the size that would be consumed, though many of the dace and whitefish were larger than this.

Movements of Young-of-the-Year Arctic Grayling

The 'spawning flags' placed in locations where MDFWP personnel captured spawning grayling during the Spring of 1989 were often close to the areas where large concentrations of YOY grayling were found. Spawning typically took place on "riffle areas with clean surface gravel which appeared 'bright' near pool or run habitats" (Shepard and Oswald 1989). The flags that marked these areas were often on riffles immediately upstream or downstream of the capture sites (which were often in pool or run habitats), thus it seems likely that grayling reared in an area stay in that area through at least their first summer. Work by Kaya (1989) showed that Big Hole River Arctic grayling fry exhibited the greatest tendency to remain stationary (maintain their position with respect to linear flow) in an artificial stream current of four populations he examined.

Twenty-nine YOY grayling were marked in one area (in section G) of which 11 were later recaptured. Nine of these were recaptured in the same general area about three weeks later and two were recaptured approximately 100 feet upstream three days after initial capture. This supports the idea that these fish are loyal to a given area (which may be as large as one riffle-pool-riffle complex). Direct observation suggests there may have been some daily movement among the YOY grayling within an area. It appeared that the fish would remain in or near aquatic vegetation in pool or run areas until about 1000 MDT (when water temperature reached about 59 F) when they would move upstream closer to riffles to begin surface-feeding on small mayfly spinners. This daily type of movement was supported, though not

conclusively, by capture in grids.

Conclusions and Recommendations

The Arctic grayling population in the Big Hole River system has been detrimentally impacted by an unknown combination of factors in the recent past. Changes in water use, land use, and the introduction of non-native species are among the factors which could have contributed to an overall decline in the grayling population. The isolation of factors that may be contributing to the decline of this population is difficult in a system as large as the Big Hole River drainage. Studies such as this, which focus on the present distribution of, and habitat utilization by, a particularly sensitive segment of the population (the young-of-the-year) are important and useful in that they add to the base of knowledge available for future management decisions and serve as pieces in the puzzling question of why this population is so rapidly declining.

Work by Skaar (1989), Shepard and Oswald (1989), Liknes (1981), and Kaya (1989) has brought forth information on the distribution, habitat utilization, and behavior of these fish. Much more work is needed however before the problem of the declining grayling can be remedied. The Montana Department of Fish, Wildlife and Parks has collected fertilized eggs from one spawning season (1988) and planted the fry in a mountain lake for future brood stock of Big Hole River Arctic grayling in the event that they are needed to restock or supplement the population in the Big Hole River. This type of management may be largely ineffective, however, until the problems within the system are identified and steps are taken to lessen their negative effects.

Laboratory studies on interspecific competition between grayling, brook trout, and brown trout will help to clarify the role of introductions of brook trout and brown trout in the decline of the grayling. Thermal studies concerning the tolerances of all life stages of grayling as well as continued field studies, particularly those focusing on the winter habitat use of the grayling and the other salmonids and land and water use in the Big Hole River Valley, are

needed to make the information available for future managers more complete.

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